Activity 4 Volcanic Hazards: Airborne Debris

Goals

In this activity you will:

- Understand why ash from volcanic eruptions can affect a much larger region than lava, pyroclastic flows, or lahars.
- Define tephra and describe some of the hazards it creates.
- Interpret maps and graph data from volcanic eruptions to understand the range in scale of volcanic eruptions.
- Understand that the explosive force of a volcano is not the only factor that determines its potential to cause loss of life and property.
- Interpret maps of wind speed and direction to predict the movement of volcanic ash.

Think about It

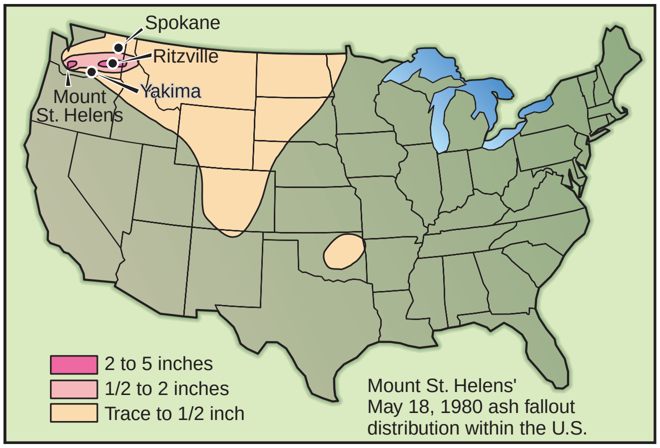
Volcanic ash put into the stratosphere from the great eruption of Krakatoa in Indonesia (see **Getting Started** on page two) caused spectacular sunsets all around the world for many months.

- Could material from a volcanic eruption ever reach your community? Explain your ideas.

What do you think? Record your ideas about this question in your *EarthComm* notebook. Be prepared to discuss your responses with your small group and the class.

Investigate

1. Look at the map of the 1980 eruption of Mt. St. Helens. It shows the pattern of ash. Use the map to answer the following questions:



Distribution of ash from Mt. St. Helens eruption.

a) How many states showed at least a trace of volcanic ash?

b) In what direction did the ash move?

c) Was Canada affected by ash from Mt. St. Helens? Why or why not?

d) Would you consider this a small, medium, large, or gigantic eruption? Explain your choice.

2. Make a bar graph of the data shown in the table.

a) Plot the name of each volcano on the horizontal axis.

b) Plot the volume of volcanic eruption on the vertical axis. Arrange the volumes in order from least to greatest.

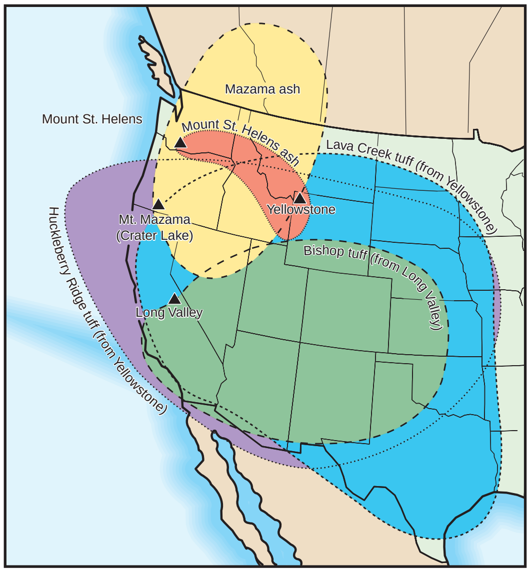
Volumes of Volcanic Eruptions

Volcano	Date	Volume (cubic kilometers)
Ilopango, El Salvador	300	40
Krakatoa, Indonesia	1883–84	2.4
Long Valley, California (Bishop Tuff)	740,000 years ago	500
Mazama, Oregon	4000 B.C.	75
Mt. Pelée, Martinique	1902	0.5
Mt. St. Helens, Washington	1980	1.25
Nevado del Ruiz, Colombia	1985	0.025
Pinatubo, Philippines	1991	10
Santorini, Greece	1450 B.C.	60
Tambora, Indonesia	1815	150
Valles, New Mexico	1.4 million years ago	300
Vesuvius, Italy	79	3
Yellowstone, Wyoming (Lava Creek Ash)	600,000 years ago	1000

Note: Volumes are approximate.

3. Use your graph and the table to answer the following questions. Record your answers in your notebook.
   a) Can you group the eruptions by size (small, medium, and so on)? Mark the groups on your plot. Explain how you chose the groups.
   b) What group does the 1980 eruption of Mt. St. Helens fit into?
   c) Suppose you wanted to predict the area that would be covered with ash by each eruption. What other information (besides volume erupted) would help you to predict how far the ash would go?

4. The following map shows the areas covered by five of the eruptions in the data table. Use the map, data table, and your bar graph to do the following:
   a) Rank the area of eruptions in order from smallest to largest. Record your rankings.
   b) Compare the areas to the volumes. Describe any relationships.
   c) Compare the location of each volcano to the path of the ash. Describe any patterns. What might explain any patterns you see?



Reflecting on the Activity and the Challenge

This activity gave you a chance to explore factors that affect the movement of volcanic ash. How did this change your ideas about the areas that can be affected by an erupting volcano? Be sure to include the effect of airborne volcanic hazards into your story line.

Digging Deeper

AIRBORNE RELEASES

Particle Types

Tephra is a term for pieces of volcanic rock and lava that are ejected into the air. It ranges from less than 0.1 mm to more than one meter in diameter. Tephra is classified by size. Names for sizes of tephra include **volcanic bombs** (greater than 64 mm), **lapilli** (between 2 and 64 mm), and **ash** (less than 2 mm). Bombs and lapilli usually fall to the ground on or near the volcano. Ash can travel hundreds to thousands of kilometers. (See *Figure 1*.) The height of the ash and the wind speed control how far the ash travels.

Distribution

A volcanic eruption can send ash many kilometers into the atmosphere. Ash from the 1980 eruption of Mt. St. Helens reached a height of 19 km. Winds carried the ash to the east. Five days after the eruption, instruments in New England detected ash. An eruption at Yellowstone 2 million years ago produced 1000 times as much ash. An area of 1000 km^2 received one meter of ash. Ten centimeters of ash covered an area of 10,000 km^2. You could look at it this way: if the ash from St. Helens filled a shoe box, the ash from Yellowstone would fill a bedroom to a depth of a meter!

Geo Words

tephra: a collective term for all the particles ejected from a volcano and transported through the air. It includes volcanic dust, ash, cinders, lapilli, scoria, pumice, bombs, and blocks.

volcanic bomb: a blob of lava that was ejected while viscous and received a rounded shape (larger than 64 mm in diameter) while in flight.

lapilli: pyroclastics in the general size range of 2 to 64 mm.

ash: fine pyroclastic material (less than 2 mm in diameter).

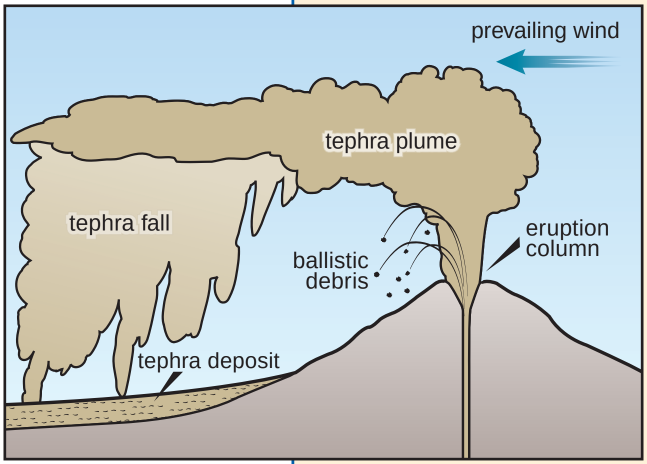


Figure 1 Ballistic debris refers to volcanic bombs and lapilli that fall on or near the volcano. Ash can travel much further.

Hazards of Volcanic Ash

Volcanic ash presents many kinds of hazards. Ash that falls on homes, factories, and schools can collapse roofs. More than 300 people died after the 1991 eruption of Mt. Pinatubo in the Philippines. Most of these deaths were caused by roof collapse. At ground level, fine ash causes breathing problems in humans and animals. It can also damage automobile and truck engines. Ash that coats the leaves of plants interferes with photosynthesis. Ash injected higher into the atmosphere can damage aircraft. In the last 15 years, 80 commercial aircraft have been damaged as they flew through volcanic ash. The only death outside the immediate area of Mt. St. Helens occurred from the crash of a small plane that was flying through the ash. Ash that falls on the slopes of a volcano poses great risk. When soaked by rain, loose ash can form lahars. Years after the eruption, lahars remain a source of concern to communities at the base of Mt. Pinatubo.

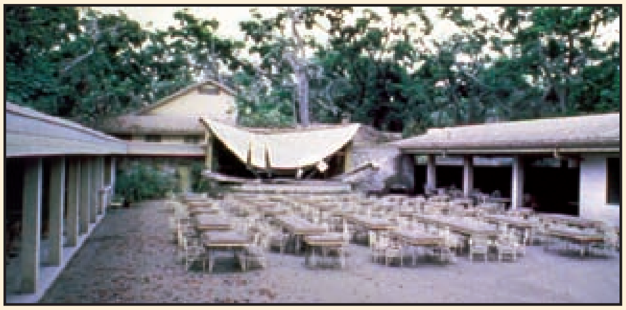


Figure 2 Volcanic ash landing on buildings can result in death. Volcanic ash is also a hazard to airplanes on the ground as well as in the air.

Volcanic Explosivity Index

The table in *Figure 3* is a scale of eruption magnitude. The scale is known as **Volcanic Explosivity Index**, or VEI. The VEI is based on the volume of erupted material and the height it reaches. The size of an eruption depends upon several factors. Two important factors are the composition of the magma and the amount of gas dissolved in the magma. The viscosity of a magma depends on two things: the temperature of the magma, and its chemical composition. The higher the silica content of magma, the more viscous it is. The more viscous it is, the more likely it is for gas pressure to build. High-silica volcanoes, like Yellowstone, erupt extremely violently, but on a scale of tens or hundreds of thousands of years. Volcanoes with intermediate silica contents, like Mt. St. Helens, commonly produce violent eruptions with a frequency of hundreds or thousands of years. Silica-poor magmas, like those erupted at Kilauea, feed less explosive eruptions that occur more often.

Volcanic Explosivity Index (VEI)

VEI	Plume Height	Volume	How often	Example
0	<100 m	1000's m^3	Daily	Kilauea
1	100–1000 m	10,000's m^3	Daily	Stromboli
2	1–5 km	1,000,000's m^3	Weekly	Galeras, 1992
3	3–15 km	10,000,000's m^3	Yearly	Ruiz, 1985
4	10–25 km	100,000,000's m^3	10's of years	Galunggung, 1982
5	>25 km	1 km^3	100's of years	St. Helens, 1980
6	>25 km	10's km^3	100's of years	Krakatoa, 1883
7	>25 km	100's km^3	1000's of years	Tambora, 1815

Figure 3

Geo Words

Volcanic Explosivity Index: the percentage of pyroclastics among the total products of a volcanic eruption.

Check Your Understanding

1. Review any words from the **Digging Deeper** sections of the previous activities that are used in this section but may still be unfamiliar to you. Briefly explain the meaning of each of the following terms: lahar, pyroclastic flow, caldera.
2. In your own words explain the meaning of tephra and how volcanic bombs, lapilli, and ash relate to tephra.
3. Name two factors that can affect the distance that volcanic ash can travel.
4. How does the silica content of magma affect how explosive a volcano can be?
5. a) What does VEI represent?

   b) Is VEI on its own a good indicator of the dangers involved with a volcanic eruption? Explain your answer.

It might seem that the number of deaths caused by an eruption should always increase as the VEI increases. The table of VEI and deadliest eruptions in *Figure 4* shows that this is not the case. For example, mudflows after the 1985 eruption of Nevado del Ruiz (Colombia) killed more than 25,000 people. This was the worst volcanic disaster since Mount Pelée in 1902. However, both eruptions had a VEI below five. Of the seven most deadly eruptions since 1500 A.D., only Tambora and Krakatoa erupted with greater explosive force (VEI above 5).

Volcanic Explosivity Index (VEI) of the Deadliest Eruptions since 1500 A.D.

Eruption	Year	VEI	Casualties
Nevado del Ruiz, Colombia	1985	3	25,000
Mount Pelée, Martinique	1902	4	30,000
Krakatoa, Indonesia	1883	6	36,000
Tambora, Indonesia	1815	7	92,000
Unzen, Japan	1792	3	15,000
Lakagigar (Laki), Iceland	1783	4	9000
Kelut, Indonesia	1586	4	10,000

Figure 4

Tambora erupted in 1815. It had a VEI of 7. Pyroclastic flows streamed down its slopes. Ash rose 44 km. About 150 km^3 of ash were erupted (about 150 times more than the 1980 eruption of Mt. St. Helens). A caldera formed when the surface collapsed into the emptying magma chamber. The Tambora caldera is 6 km wide and 1.1 km deep. Tephra fall, a tsunami (a giant sea wave caused by the explosion), and pyroclastic flows killed about 10,000 people. More than 82,000 people died from famine. It is thought that the ash shortened the growing season.

Understanding and Applying What You Have Learned

1. In your own words, compare the sizes of the areas affected by lava, pyroclastic flows, and ash falls.
2. Is volcanic ash a concern only in the western United States? Explain your answer.
3. Why do eruptions in Hawaii differ from the Mt. St. Helens eruption?
4. Look at your list of the three volcanoes that are closest to your community. Go to the AGI *EarthComm* web site to find out how to simulate the eruption of one of your three volcanoes on the Internet. Simulate the eruption of one of your three volcanoes.
   a) Print out and describe the paths of the ash from the simulation.
   b) What do the maps tell you about the prevailing wind directions for your community?
   c) Do the prevailing wind directions change seasonally in your area? If yes, how would this affect the pattern of ash fallout?

Preparing for the Chapter Challenge

In **Activity 1** you were asked to describe to your audience the place that you thought a volcanic eruption was most likely to occur. Did you leave the impression in your story that this was the only area to be affected by the eruption? Think about how your study of the movement and hazards of volcanic ash has changed your ideas. Be sure to include this information in your story.

Inquiring Further

1. **Make a model of tephra transport**

   Build a model of a volcano that has exploded (Mt. St. Helens). Run a tube up through the vent of the volcano. Mix a small amount of baby powder with some sand. Use a funnel to pour the sand mixture down the other end of the tube. Attach a bicycle pump to pump the sand out of the volcano. Use a fan or hair dryer to simulate winds.

   Devise a method to outline the distribution of material when there is no wind, weak wind, and strong wind. Compare how far the sand travels and how far the baby powder travels. Consider the factors of particle size, wind speeds, wind direction, and topography. As part of your **Chapter Challenge** you may wish to include a presentation and explanation of your model.

Use eyewear whenever non-water liquids and/or particles such as sand are used. If this activity is done indoors use a large, clear area. Clean the area well when you are done. Sand on the floor can be slick.